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PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference PH0337-PCT	FOR FURTHER ACTION See Form PCT/IPEA/416	
International application No. PCT/GB2004/002340	International filing date *(day/month/year)* 03.06.2004	Priority date *(day/month/year)* 04.06.2003
International Patent Classification (IPC) or national classification and IPC G01T1/166		
Applicant HAMMERSMITH IMANET LTD et al.		

1. This report is the International preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 5 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 6 sheets, as follows:
      ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☒ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
04.04.2005	09.06.2005
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Lahorte, P Telephone No. +49 89 2399-7226

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/GB2004/002340

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages	
1-4, 6-16	as originally filed
5, 5a	received on 04.04.2005 with letter of 04.04.2005
Claims, Numbers	
1-23	received on 04.04.2005 with letter of 04.04.2005
Drawings, Sheets	
1/6-6/6	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☒ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☒ the claims, Nos. 1, 12
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	
	No:	Claims	1, 12, 23
Inventive step (IS)	Yes:	Claims	
	No:	Claims	2, 5, 6, 8, 13, 16, 17, 19
Industrial applicability (IA)	Yes:	Claims	1-23
	No:	Claims	

Citations and explanations (Rule 70.7):

see separate sheet

1. The following documents are referred to in this communication:
   D2 : SPINKS T J ET AL: "Physical characteristics of the ECAT EXACT3D positron tomograph" PHYS. MED. BIOL., vol. 45, 2000, pages 2601-2618, XP002297164

Re Item I.

2. The amendments to claims 1 and 12, filed with the letter dated 04.04.2005, introduce subject-matter which extends beyond the content of the application as filed, contrary to Article 34(2)(b) PCT, for the following reasons:
   the features of original claim 3 have been disclosed in combination.
   Merely incorporating the feature "a coincidence detection system for producing coincidence count data (M_{ij}) during an acquisition when a positron source is inside the scanner" into claims 1 and 12 without also incorporating the remaining features of original claim 3 ("wherein the scanner is arranged to produce artificial coincidence count data (M'_{ij}) during ... comprises processing said artificial coincidence count data") into claims 1 and 12, results in a combination of features which has not been disclosed in the original application. The subject-matter of amended claims 1 and 12 therefore goes beyond the disclosure of the international application as filed, in violation of Article 34(2)(b) PCT.
   For this reason this report has been established as if the abovementioned feature of the coincidence detection system had not been incorporated into claims 1 and 12.

Re Item V.

3. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of **claim 1**, as well as of the corresponding independent computer software **claim 12** and data carrier **claim 23**, is not new in the sense of Article 33(2) PCT, for the following reasons: document D2 discloses (e.g. see abstract) a method for generating detector efficiency data for a positron emission tomography scanner (a "ECAT EXACT3D" positron tomograph) including a detector array, a single-photon source (i.e. ^{137}Cs), conducting an acquisition procedure (page 2603, penultimate paragraph;) and processing said detection data (page 2603, final paragraph; page 2604, paragraph "2.2.3"; page 2609, paragraph "3.3") as defined by claim 1.
4. Dependent **claims 2, 5, 6, 8, 13, 16, 17 and 19** do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements

of the PCT in respect of novelty and/or inventive step (Article 33(2) and (3) PCT).

start and end of the procedure. It is also potentially hazardous, in terms of lifting the phantom and exposure to radioactivity.

It would be desirable to be able to estimate detector efficiency data in PET scanners of a type which use a single photon source for transmission scans, without the drawbacks of using a phantom scan.

In accordance with one aspect of the present invention there is provided a method of generating detector efficiency data for a positron emission tomography scanner which is arranged to conduct an emission scan by detecting dual photons emitted as a result of an annihilation of a positron emitted during a radioactive decay, said scanner including:

a detector array for generating detection data;

a single photon source containing a radioactive material which, during a radioactive decay, emits only a single photon; and

a coincidence detection system for producing coincidence count data during an acquisition when a positron source is inside the scanner,

wherein the method comprises:

conducting an acquisition procedure using the single photon source to produce detection data; and

processing said detection data using an efficiency estimation algorithm to calculate data representative of the efficiencies of individual detectors in said array.

By enabling the estimation of detector efficiencies from an acquisition using the single photon source, detector efficiencies can be generated without significant inconvenience to an operator. The detector efficiencies may be derived from a blank scan acquisition conducted at the operator's convenience. Furthermore, the regular need for the use of a phantom scan procedure can be avoided.

In a preferred embodiment of the invention, detector efficiency estimates are made using the artificial coincidence counts generated during a blank scan acquisition made using the single photon source. Typically, artificial coincidence

counts are the only suitable detection data made available as an output from a scanner of a type such as an ECAT EXACT3D PET scanner. However, detector efficiency data cannot be accurately estimated from artificial coincidence counts using known techniques, because the known measurement models do not apply. The present invention provides a new measurement model and exemplary efficiency estimation algorithms, which can be applied to artificial coincidence counts produced using blank scans.

Replacement Claims

1. A method of generating detector efficiency data for a positron emission tomography scanner which is arranged to conduct an emission scan by detecting dual photons emitted as a result of an annihilation of a positron emitted during a radioactive decay, said scanner including:

a detector array for generating detection data;

a single photon source containing a radioactive material which, during a radioactive decay, emits only a single photon; and

a coincidence detection system for producing coincidence count data during an acquisition when a positron source is inside the scanner,

wherein the method comprises:

conducting an acquisition procedure using the single photon source to produce detection data; and

processing said detection data using an efficiency estimation algorithm to calculate data representative of the efficiencies of individual detectors in said array.

2. A method according to claim 1, where said acquisition procedure includes a blank scan acquisition.

3. A method according to claim 1 or 2, wherein the scanner is arranged to produce artificial coincidence count data during an acquisition using the single photon source, and wherein the step of processing said detection data comprises processing said artificial coincidence count data.

4. A method according to claim 3, wherein the efficiency estimation algorithm is based upon a measurement model which is additive, in that the measured counts of a particular artificially coincident pair of detectors is related to a weighted sum of their individual efficiencies.

5. A method according to any preceding claim, wherein the scanner is a non-rotating scanner.

6. A method according to any of claims 1 to 4, wherein the scanner is a rotating scanner.

7. A method according to claim 6, wherein the scanner comprises two single photon sources and the method comprises selectively operating one of the two single photon sources during the acquisition procedure.

8. A method according to any preceding claim, further comprising generating an output, responsive to said data representative of efficiencies, on an output device for an operator.

9. A method according to any preceding claim, comprising processing said data representative of efficiencies to identify detector elements, or groups of detector elements having relatively low efficiencies.

10. A method according to claim 9, comprising processing said data representative of efficiencies using a function determining a parameter relating to an average over a plurality of detector elements.

11. A method according to claim 9 or 10, comprising processing said data representative of efficiencies using a function determining a parameter relating to an amount of variation therein.

12. Computer software for generating detector efficiency data for a positron emission tomography scanner which is arranged to conduct an emission

scan by detecting dual photons emitted as a result of an annihilation of a positron emitted during a radioactive decay, said scanner including:

a detector array for generating detection data;

a single photon source containing a radioactive material which, during a radioactive decay, emits only a single photon; and

a coincidence detection system for producing coincidence count data during an acquisition when a positron source is inside the scanner,

wherein the software is adapted to operate on detection data generated by conducting an acquisition procedure using the single photon source, and

wherein the software is adapted to process said detection data using an efficiency estimation algorithm to calculate data representative of the efficiencies of individual detectors in said array.

13. Computer software according to claim 12, where said acquisition procedure includes a blank scan acquisition.

14. Computer software according to claim 12 or 13, wherein the scanner is arranged to produce artificial coincidence count data during an acquisition using the single photon source, and wherein the software is adapted to operate on said artificial coincidence count data.

15. Computer software according to claim 14, wherein the efficiency estimation algorithm is based upon a measurement model which is additive, in that an efficiency of a particular artificially coincident pair of detectors is related to a sum of their individual efficiencies.

16. Computer software according to any of claims 12 to 15, wherein the scanner is a non-rotating scanner.

17. Computer software according to any of claims 12 to 15, wherein the scanner is a rotating scanner.

18. Computer software according to claim 17, wherein the scanner comprises two single photon sources and the method comprises selectively operating one of the two single photon sources during the acquisition procedure.

19. Computer software according to any of claims 12 to 18, wherein the software is adapted to generate an output, responsive to said data representative of efficiencies, on an output device for an operator.

20. Computer software according to any of claims 12 to 19, wherein the software is adapted to process said data representative of efficiencies to identify detector elements, or groups of detector elements having relatively low efficiencies.

21. Computer software according to claim 20, wherein the software is adapted to process said data representative of efficiencies using a function determining a parameter relating to an average over a plurality of detector elements.

22. Computer software according to claim 20 or 21, wherein the software is adapted to process said data representative of efficiencies using a function determining a parameter relating to an amount of variation therein.

23. A data carrier comprising computer software according to any of claims 12 to 22.